PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G02B 27/01 — A1

(11) International Publication Number: WO 99/31543

(43) International Publication Date: 24 June 1999 (24.06.99)

(21) International Application Number: PCT/GB98/03744

(22) International Filing Date: 14 December 1998 (14.12.98)

(30) Priority Data:
9726413.9 15 December 1997 (15.12.97) GB

(71) Applicant *(for all designated States except US)*: RETINAL DISPLAY CAYMAN LIMITED [–/–]; One Capital Place, Grand Cayman (KY).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: MARSHALL, Ian [GB/GB]; 31 Northease Drive, Hove, East Sussex BN3 8PQ (GB).

(74) Agent: SPOOR, Brian; Lewis & Taylor, 144 New Walk, Leicester LE1 7JA (GB).

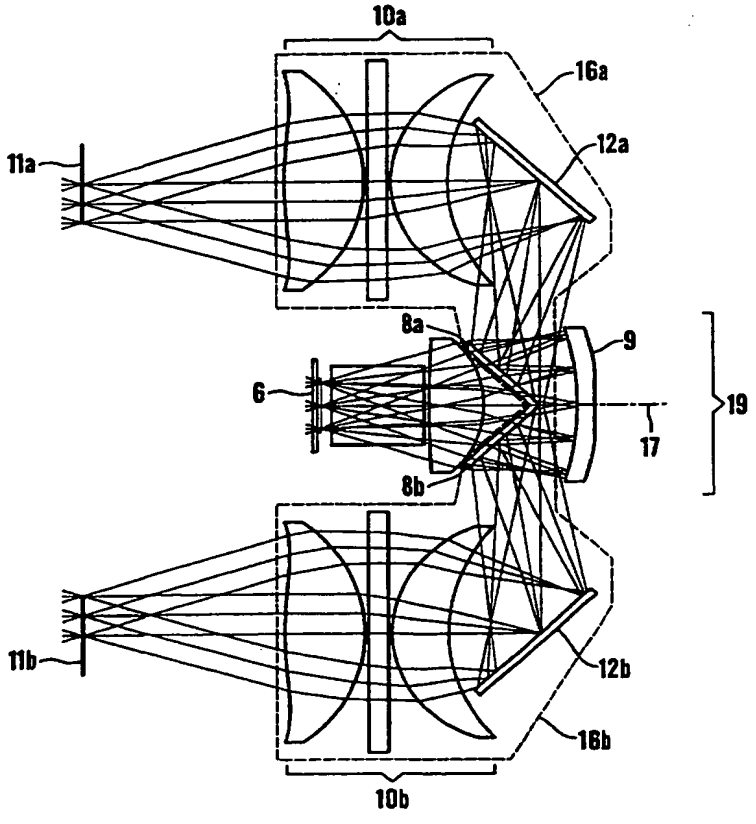
(81) Designated States: JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: BINOCULAR IMAGE DISPLAY APPARATUS

(57) Abstract

Light from an image generator (1) of a head–worn binocular image display apparatus passes through a pair of angled beamsplitters (8a, 8b) to be deflected back towards the latter by a beam deflector, such as a concave mirror (9). The light is then deflected by the beamsplitters (8a, 8b) into left and right paths towards left and right eyepieces (10a, 10b) which enable viewing by a user of the image produced by the generator (1). The left beamsplitter (8a) and the left eyepiece (10a) are rotatable together relative to the image generator (1), while the right beamsplitter (8b) and the right eyepiece (10b) are rotatable together relative to the image generator (1) on the one hand and relative to the left beamsplitter (8a) and the left eyepiece (10a) on the other in order to adjust the interpupillary distance of the users.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

BINOCULAR IMAGE DISPLAY APPARATUS

This invention relates to display apparatus of the type which permits of binocular viewing of an image. In particular, it is concerned with display apparatus for viewing video or computer generated information.

In the past, a display apparatus has been developed which incorporates a single display, such as a reflective liquid crystal display, and a beamsplitter arrangement to divide light issuing from the display into two eyepieces.

The beamsplitter arrangement consists of two semi-reflecting beamsplitting elements disposed one above the other and mutually inclined at an angle of substantially 90^0. A satisfactory display is achieved by displacing the apparatus relative a reference, such as a casing for the apparatus, sot that the exit pupils produced by the beamsplitter arrangement and subsequent eyepieces are arranged to overlay the user's eyes, so that the user can clearly see the whole field of view.

It is an object of the invention to provide improvements to the above described arrangement. According to the invention, there is provided a display apparatus comprising: a frame for retaining the apparatus in place relative to the head of a user,

image generating means for generating an image for viewing by a user,

and an optical system for projecting an image in use to the eyes of a user, the optical system comprising:

beamsplitting means for directing light from an image of the image generating means into left and right paths, the beamsplitting means comprising left and right semi-reflecting devices, said devices being mutually inclined and disposed adjacent one another,

beam deflecting means for projecting light from the image generating means to the beamsplitting means, and

left and right eyepieces for viewing images relayed along the left and right paths respectively, wherein the left semi-reflecting device and the left eyepiece are together rotatable relative to the image generating means, and the right semi-reflecting device and the right eyepiece are together rotatable relative to the image generating means and the left semi-reflecting device and the left eyepiece.

In that way, the distance between the left and right eyepieces can be varied, rendering the apparatus capable of accommodating a wide range of interpupillary distance of users. By virtue of the above, the apparatus can be adjusted so that small exit pupils are viable, since they can overlay the eyes of a user.

The above provides the potential for less massive and bulky displays, and optical components, and therefore to greater comfort for the user.

In a preferred embodiment of the invention, the left and right semi reflecting devices are disposed substantially horizontally adjacent one another.

According to a preferred embodiment of the invention, the beam deflecting means comprises a concave mirror.

In a preferred embodiment of the invention, each eyepiece has an optical axis, the optical axes of the eyepieces being substantially parallel with the principal optical axis of the concave mirror.

Preferably, each eyepiece and respective semi-reflecting device is rotatable about the principal optical axis of the concave mirror.

Each eyepiece is preferably provided with magnifying/collimating means for magnifying/collimating a relayed image in use for viewing at a respective exit pupil.

The image generating means may comprise a liquid crystal display. Preferably, the liquid crystal display is of the reflective type. The image generating means may further comprise illumination means, including an illumination beamsplitter. Preferably, the illumination beamsplitter is interposed between the liquid crystal display and the beamsplitting means.

As an alternative to a liquid crystal display, the image generating means may comprise an electroluminescent panel.

One or more lenses may be interposed between the image generating means and the concave mirror.

Each eyepiece may comprise one or more lenses. Moreover, the eyepiece may comprise one or more holographic lenses.

The beam deflecting means may include several refracting means, and a reflecting surface.

An exemplary embodiment may include a Mangin mirror.

The beam deflecting means may comprise left and right concave mirrors, each corresponding to respective eyepiece and beamsplitting means.

Further aspects and preferred features of the invention will be apparent from the following description of a specific embodiment of the invention, by way of example only, illustrated in the accompanying drawings, in which:

Figure 1 is a perspective schematic view of the left hand half of a display apparatus in accordance with a specific embodiment of the invention;

Figure 2 is a side elevational view of illumination optics of the display apparatus illustrated in Figure 1;

Figure 3 is a front elevational view of the illumination optics of figure 2;

Figure 4 is a raytrace diagram of the part of the display apparatus illustrated in figure 1, in a plane including the principal optical axes of the convex mirror and the left hand eyepiece;

Figure 5 is a raytrace diagram of the complete display apparatus of the specific embodiment, in a plane as indicated in figure 6 by line V-V;

Figure 6 is an end view of the display apparatus of Figure 1, adapted for use by a person having average interpupillary distance;

Figure 7 is an end view of the display apparatus of Figure 1, adapted for use by a person having large interpupillary distance; and

Figure 8 is an end view of the display apparatus of Figure 1, adapted for use by a person having small interpupillary distance.

Referring firstly to Figures 1 and 5, a reflective liquid crystal display (LCD) 6 is provided, adjacent which is a polarising beamsplitter 5 concerned with the illumination of the LCD 6 as described further below. Adjacent the beamsplitter 5 is a field lens 7 and two beamsplitters 8a, 8b, one of which, 8a, is illustrated in figure 1. Adjacent the beamsplitters 8a, 8b is a concave mirror 9. All of the above described components are arranged along a principal optical axis 17 of the concave mirror.

The LCD 6 preferably has an image diagonal in the region of 10mm (0.4"). The illumination optics for use with the LCD, and including the beamsplitter 5 will now be described with reference to figures 2 and 3. As illustrated in figure 2, the polarising beamsplitter 5 includes

two right angle prisms 5a, 5b, having their hypotenuse surfaces adhered together with a polarising thin film coating interposed there between. The beamsplitter is commonly called a "cube", although it may have a rectangular cross section as shown in figures 2 and 3.

A light source 1, comprising an array of LED's of three colours that are illuminated sequentially, is spaced from the upper surface of the illuminating beamsplitter 5. Between the light source 1 and the beamsplitter 5, a diffuser 2, a Fresnel lens 3 to collimate the light, and a linear polariser 4 are provided, to ensure that the light incident on the LCD 6 is in an appropriate form as to ensure a clear image is generated in the LCD 6. The diffuser 2 may be a moulded plastic or fire polished glass optic with a specular rough surface. The linear polariser 4 may comprise a plastics film, preferably of polyvinylene.

The array of LCD's is triggered by a series of electronic timing signals, corresponding timing signals being sent to the LCD 6, thus allowing the development of a colour image on the LCD 6.

As shown more clearly in figure 5, the beamsplitters 8a, 8b are arranged adjacent one another, and at an angle. The beamsplitters 8a, 8b are relatively thin, and preferably a barrier such as a piece of black plastic is interposed there between so as to eliminate ghost reflections and refractions between the beamsplitters 8a, 8b.

The apparatus further comprises a pair of eyepieces 10a, 10b, of which one is shown in figure 1. Each eyepiece 10a, 10b includes two moulded plastic aspheric lenses 13a, 13b and 15a, 15b, and a holographic lens 14a, 14b.

In use, light from the light source 1 passes through the diffuser 2, the Fresnel lens 3 and the linear polariser 4, is reflected off the boundary between the two prisms 5a, 5b of the illuminating beamsplitter 5 to the LCD 6, which causes an image to be generated on the LCD 6.

Light reflected from the LCD 6 then passes back through the beamsplitter 5, generally without being reflected at the boundary due to the polarisation of the light, and through the field lens 7 and the beamsplitters 8a, 8b to the concave mirror 9. The light is then directed back to the beamsplitters 8a, 8b, which reflect the light outwards in two beams towards the eyepieces 10a, 10b. A fold mirror 12a, 12b is provided at the end of each eyepiece 10a, 10b to deflect the beam of light back to the principle optical axis of the eyepiece 10a, 10b, which is substantially parallel with the principal optical axis of the concave mirror 9. The eyepiece serves to project an exit pupil 11a, 11b.

Each eyepiece 10a, 10b, with corresponding fold mirror 12a, 12b and beamsplitter 8a, 8b, are brought together as an eyepiece sub-assembly 16a, 16b. Each eyepiece sub-assembly 16a, 16b is independently rotatable about the principal optical axis 17 of the concave mirror, relative the LCD 6.

Preferably, the sub-assemblies 16a, 16b and a central assembly 18 housing the LCD 6 and the concave mirror 9 are geared together suitably that rotation of the one sub-assembly 16a relative the central assembly 18 is complemented by identical and opposite rotation of the other subassembly 16b relative the central assembly 18, to maintain the perceived orientation of an image developed in the LCD 6.

The optical system is further described in conjunction with the data contained in Tables 1 to 6 appended hereto. Table 1 describes the geometry of the optical surfaces of the components of the display apparatus, table 2 describes the global coordinates of the components, table 3 describes the aspheric nature of certain of the optical components, table 4 describes the properties of the holographic lens 14, table 5 describes refractive indices of materials used in optical components, and table 6 describes the data necessary to generate ray coordinates to trace from the exit pupils to the display.

Note 1 in table 1 refers to the fact that the clear apertures of the plane mirrors and beamsplitters are complex shapes due to the compound rotation of the surfaces in relation to

the field of view and the exit pupils. It will be understood that these clear apertures can be calculated by constructing an optical model from the tabulating data and raytracing across the whole field of view and exit pupil. The intersections of the rays with the plane mirrors and the beamsplitter surfaces will define their clear apertures.

Note 2 in table 1 refers to the fact that the dummy surface is added to the optical model so that the centres of the concave mirror, field lens and the display are modelled on the same axis. It serves to cancel out the mathematical operation of tilting the beamsplitter.

Table 1 describes the optical surfaces of the apparatus by defining a series of surface poles in space, the optical surfaces being define from those poles which are treated as local origins for the surface data. Each optical surface has a shape defined by the radius of curvature and any associated aspheric coefficients. The surface extends over the clear aperture specified.

In table 2, the Cartesian coordinates are measured relative a global origin, taken as the centre of the nominal exit pupil. The X axis is horizontal, being parallel to the modelled optical axis of the concave mirror, the Y axis is vertical, and the Z axis is also horizontal.

The convention used in table 3 is that the aspheric coefficients define a change to the surface sag according to the normal rotationally symmetrical equation. The A4 coefficient (in mm-') adds a term proportional to aperture radius to the power 4, the A6 coefficient (in mm-') to the power 6, and the A8 coefficient (in mm-') to the power 8.

Figures 6 to 8 demonstrate how the display assembly can be adjusted to permit use by people with different interpupillary distances.

As an alternative to the foregoing, the concave mirror can readily be replaced by a pair of concave mirrors, each being associated with one of the eyepiece sub-assemblies. In that case, each concave mirror must be arranged to rotate with its respective sub-assembly, for interpupillary adjustment.

As an alternative to a concave mirror, or a pair of concave mirrors, a combination of refracting and reflecting surfaces may be used, such as a Mangin mirror, i.e. a mirror with internally reflecting surfaces and an external refracting surface. Another alternative would be a series of one or more lenses in front of a mirror, the lenses projecting the image onto the mirror, which then reflects the image back through the lenses. The lenses may include a holographic lens.

The illumination optics may be constructed as an alternative such that the illumination light is transmitted through the polarising beamsplitter and the displayed image is reflected off the polarising beamsplitter. the combinations of polarising components may be modified by rotating their polarising axes to match the alternate polarising characteristics of the abovedescribed beamsplitter arrangement. Moreover, the above alternative may be combined with the left and right concave mirror arrangement described earlier.

Table 1. Imaging Optics Optical Surface data. Dimensions in millimetres

Surface (item numbers refer to Figure 1	Radius of Curvature	Semi-Clear Aperture	Distance to next Surface	Material in the space to the next Surface
Exit Pupil item 11a	Infinity	7x7mm rectangular	30.0	Air
1st Acrylic lens surface (Aspheric) item 15	667.007 concave	20.0 circular	9.403	Acrylic
2nd Acrylic lens surface item 15	34.447 convex	20.0 circular	0.5	Air
1st Hologram substrate surface item 14	Infinity	20.0 circular	3.0	Glass. Schott BK7
2nd Hologram substrate surface (Holographic fringes on this surface.) item 14	Infinity	20.0 circular	0.5	Air

1st Polystyrene lens surface item 13	23.480 convex	19.0 circular	9.354	Polystyrene
2nd Polystyrene lens surface (Aspheric) item 13	117.470 concave	19.0 circular	12.876	Air
Plane mirror (tilted) item 12a	Infinity	see note (1)	52.205	Air (reflection)
Reflecting beamsplitter surface (tilted) item 8a	Infinity	see note (1)	6.0	Air (reflection)
Concave mirror (Aspheric) item 9	51.058 concave	15.0x11.0 rectangular	6.0	Air (reflection)
1st Refracting beamsplitter surface (tilted) item 8a	Infinity	See note (1)	1.1	Glass. Schott BK7
2nd Refracting beamsplitter surface (tilted) item 8a	Infinity	See note (1)	-1.1	Air
Dummy surface	Infinity	N/A	9.516	Air

1st Acrylic field lens surface (Aspheric) item 7	17.572 convex	12.0 circular	8.260	Acrylic
2nd Acrylic field lens surface item 7	242.325 convex	12.0 circular	0.861	Air
1st polarising beamsplitter surface item 5	Infinity	10.0x7.0 rectangular	14.0	Air
2nd polarising beamsplitter surface item 5	Infinity	10.0x7.0 rectangular	0.909	Air
Reflective liquid crystal panel output window item 6	Infinity		0.8	Crown glass, e.g. Schott AF45
Image plane	Infinity			

Table 2. Imaging Optics Global Coordinates of the Surface Poles

Surface (items numbers refer to Figure 1	Linear Coordinates of surface normal (mm)			Angular Coordinates of surface normal (degrees)	
	X	Y	Z	To X axis	To Y axis
Exit Pupil item 11a	0.0	0.0	0.0	0.0	90.0
1st Acrylic lens surface item 15	30.0	0.0	0.0	0.0	90.0
2nd Acrylic lens surface item 15	39.403	0.0	0.0	0.0	90.0
1st Hologram substrate surface item 14	39.903	0.0	0.0	0.0	90.0
2nd Hologram substrate surface item 14	42.903	0.0	0.0	0.0	90.0
1st Polystyrene lens surface item 13	43.403	0.0	0.0	0.0	90.0
2nd Polystyrene lens surface item 13	52.756	0.0	0.0	0.0	90.0
Plane mirror (tilted) item 12a	65.633	0.0	0.0	45.0	60.0

Reflecting beamsplitter surface (tilted) item 8a	65.633	36.915	36.915	45.241	59.861
Concave mirror item 9	71.633	36.915	36.915	0.0	90.0
1st Refracting beamsplitter surface (tilted) item 8a	65.633	36.915	36.915	45.241	59.861
2nd Refracting beamsplitter surface (tilted) item 8a	64.858	37.467	37.467	45.241	59.861
Dummy surface (see note(2))	65.633	36.915	36.915	0.0	90.0
1st Acrylic field lens surface item 7	56.117	36.915	36.915	0.0	90.0
2nd Acrylic field lens surface item 7	47.857	36.915	36.915	0.0	90.0
1st polarising beamsplitter surface item 5	46.996	36.915	36.915	0.0	90.0
2nd polarising beamsplitter surface item 5	32.996	36.915	36.915	0.0	90.0

Reflective liquid crystal panel output window item 6	32.087	36.915	36.915	0.0	90.0
Image Plane	31.287	36.915	36.915	0.0	90.0

Table 3. Aspheric Surface Data. All dimensions in units equivalent to mm

Surface (item numbers refer to Figure 1	Aspheric coefficients (positive coefficients make the surface more convex)		
	A4	A6	A8
1st Acrylic lens surface item 15	+1.8555e-06	-2.1025e-27	0.0
2nd Polystyrene lens surface item 13	-1.2559e-05	-3.1199e-09	0.0
Concave mirror item 9	-5.4731e-07	+6.7166e-09	-9.0662e-12
1st Acrylic field lens surface. item 7	+7.0817e-06	+2.6942e-08	0.0

Table 4 Holographic Lens. All dimensions in units equivalent to mm

Holographic fringes on the 2nd Hologram substrate (item 14)

Fring profile:

kinoform (triangular) with 1 wavelength fringe depth.

Wavelength used for calculation: 0.58756 microns.

+1 diffraction order.

Equivalent lens phase profile is $k \times p^2$, where:

p is the radius from the surface pole to any point on the hologram

$k=-0.002243\ mm^{-1}$

The holographic lens focal length is 222.956mm (converging)

Table 5. Refractive Index Data

Material Type	Refractive index at the following wavelengths (quoted in microns)			Abbe dispersion value
	0.58756	0.48613	0.65627	
Acrylic	1.490082	1.496037	1.487570	57.880768
Polystyrene	1.590496	1.604080	1.584950	30.868442
Schott BK7	1.516800	1.522376	1.514322	64.166410
Schott AF45	1.525500	1.531343	1.522944	62.562503

Table 6. Paraxial setup data. All dimensions millimetres

The exit pupils are nominally rectangles with width 14 mm and height 7 mm, centred on the optical axis of the eyepiece lenses.

The field of view is 38 degrees wide and is modelled with an f-tan theta mapping function over a 4:3 aspect ratio. It's height is 28 degrees.

CLAIMS

1. Display apparatus comprising:

a frame for retaining the apparatus in place relative to the head of a user;

image generating means (1) for generating an image for viewing by the user; and

an optical system for projecting the image in use to the eyes of the user, the optical system comprising:

beamsplitting means (8a,8b) for directing light from the image generating means (1) into left and right paths, the beamsplitting means comprising left (8a) and right (8b) semi-reflecting devices, said devices being mutually inclined and disposed adjacent to one another,

beam deflecting means (9) for projecting light from the image generating means to the beamsplitting means, and

left (10a) and right (10b) eyepieces for viewing images relayed along the left and right paths respectively,

characterised in that the left semi-reflecting device (8a) and the left eyepiece (10a) are together rotatable relative to the image generating means (1), and the right semi-reflecting device (8b) and the right eyepiece (10b) are together rotatable relative to the image generating means (1) and also relative to the left semi-reflecting device (8a) and the left eyepiece(10a).

2. Display apparatus as claimed in claim 1, wherein the left and right semi-reflecting devices (8a, 8b) are disposed substantially horizontally adjacent one another.

3. Display apparatus as claimed in claim 1 or 2, wherein the beam deflecting means comprises a concave mirror (9).

4. Display apparatus as claimed in claim 3, wherein each eyepiece (10a,10b) has an optical axis, these optical axes being substantially parallel with the principal optical axis of the concave mirror (9).

5. Display apparatus as claimed in claim 3 or 4, wherein each eyepiece (10a, 10b) and the respective semi-reflecting device (8a,8b) is rotatable about the principal optical axis of the concave mirror (9).

6. Display apparatus as claimed in any preceding claim, wherein each eyepiece (10a,10b) is provided with magnifying/collimating means for magnifying/collimating a relayed image in use for viewing at a respective exit pupil.

7. Display apparatus as claimed in any preceding claim, wherein the image generating means (1) comprises a liquid crystal display.

8. Display apparatus as claimed in claim 7, wherein the image generating means (1) further comprises illumination means, including an illumination beamsplitter(5).

9. Display apparatus as claimed in claim 8, wherein he illumination beamsplitter (5) is interposed between the liquid crystal display (1) and the beamsplitting means (8a,8b).

10. Display apparatus as claimed in any one of claims 1 to 6, wherein the image generating means (1) comprises an electroluminescent panel.

11. Display apparatus as claimed in claim 3,4 or 5 wherein one or more lenses (7) are interposed between the image generating means (1) and the concave mirror (9).

12. Display apparatus as claimed in any preceding claim, wherein each eyepiece (10a,10b) comprises one or more holographic lenses.

13. Display apparatus as claimed in any preceding claim, wherein the beam deflecting means (9) includes refracting means and a reflecting surface, such as a Mangin mirror.

14. Display apparatus as claimed in any of claims 1 to 12, wherein the beam deflecting means (9) comprises left and right concave mirrors, each of which is operative to deflect light from one of the beamsplitter devices (8a,8b) to the respective eyepiece (10a,10b).

15. Display apparatus comprising:

an image generator (1) operative to generate an image for viewing by a user; and an optical system operative to project the image to eyes of the user, the optical system including:

beamsplitting means (8a,8b) comprising first and second beamsplitter devices operative to direct light from the image generator (1) towards the left and right eyes of the user along first and second paths, respectively:

deflecting means (9) disposed optically on the opposite side of the beamsplitting means (8a,8b) to the image generator (1) and operative to deflect light passing through the beamsplitting means (8a,8b) from the image generator (1) back towards the beamsplitting means (8a,8b) for subsequent deflecting by the latter into said first and second paths; and

left and right eyepieces (10a,10b) by means of which the user may view the images projected along the first and second paths, respectively;

characterised in that the first beamsplitter device (8a) and the left eyepiece (10a) are angularly movable in unison relative to the image generator (1) the second beamsplitter

device (8b) and the right eyepiece (10b) are angularly movable in unison relative to the image generator (1) and also relative to the first beamsplitter device (8a) and the left eyepiece (10a).

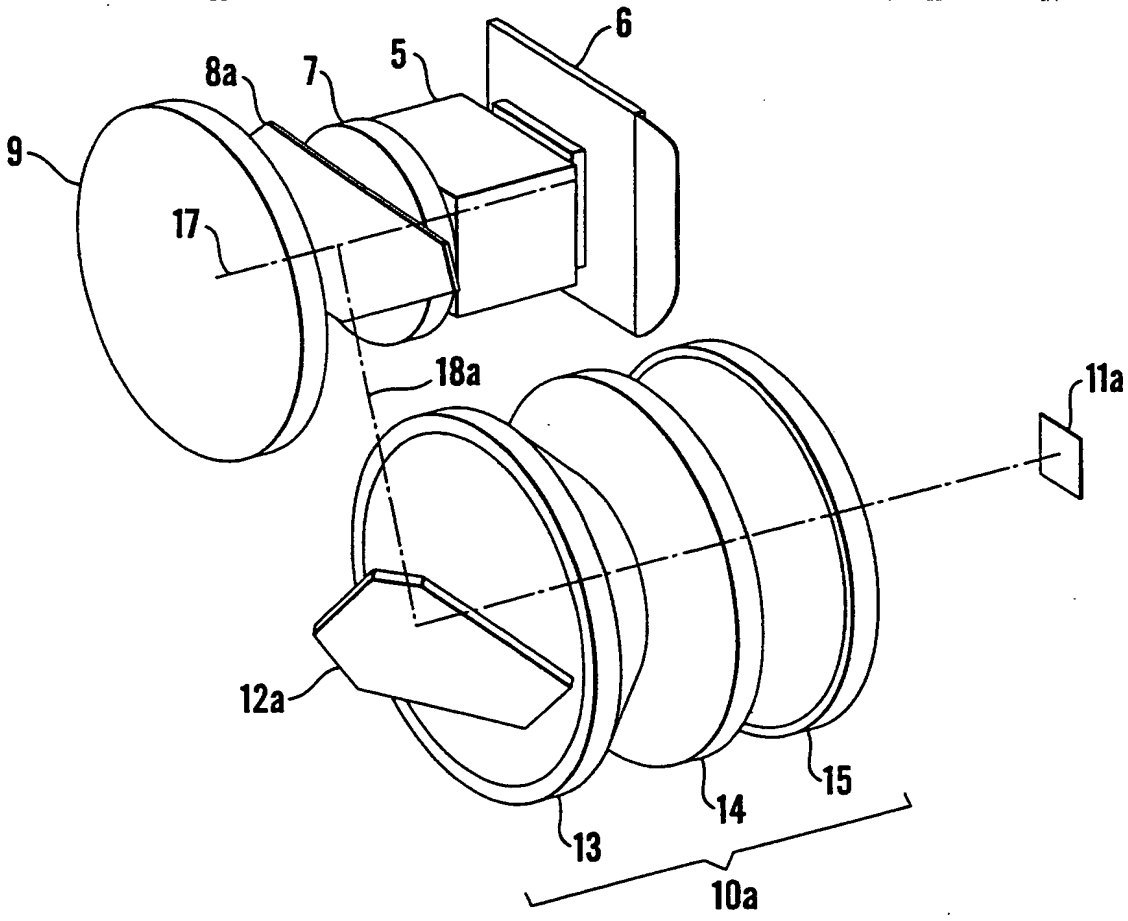


Fig. 1

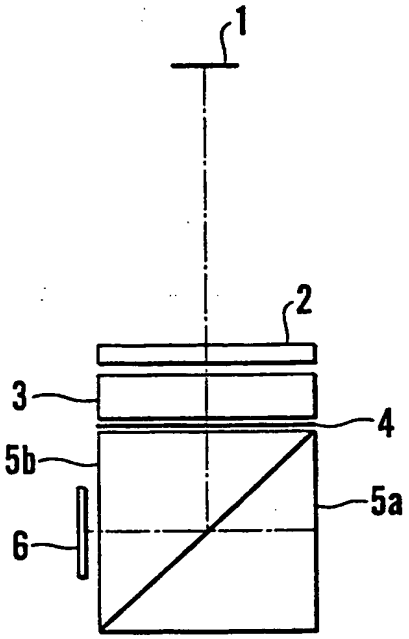


Fig.2

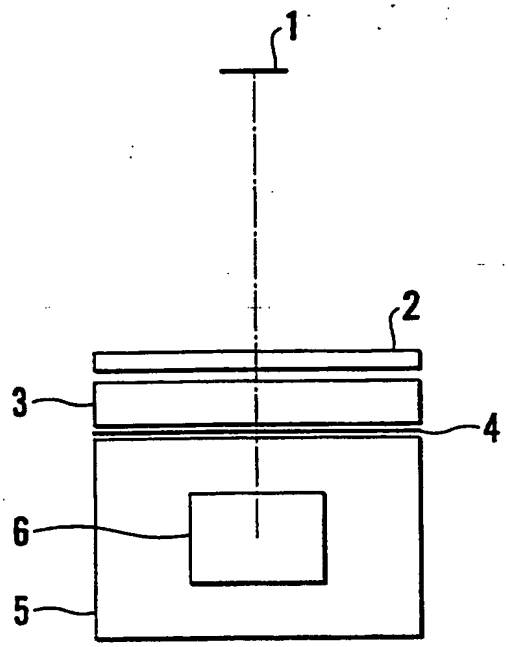


Fig.3

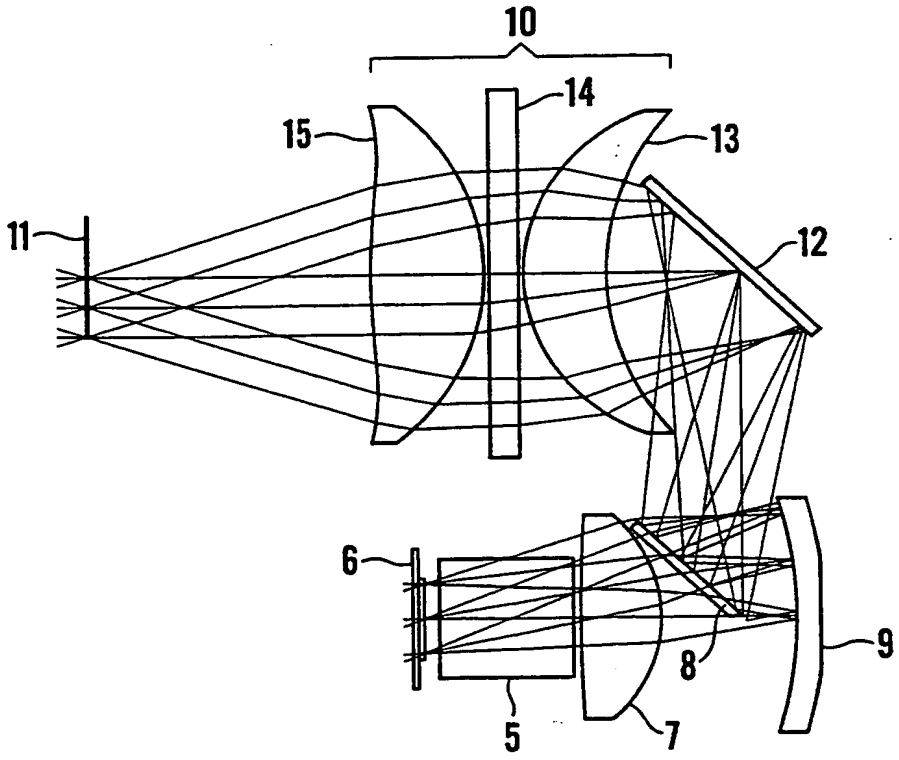


Fig.4

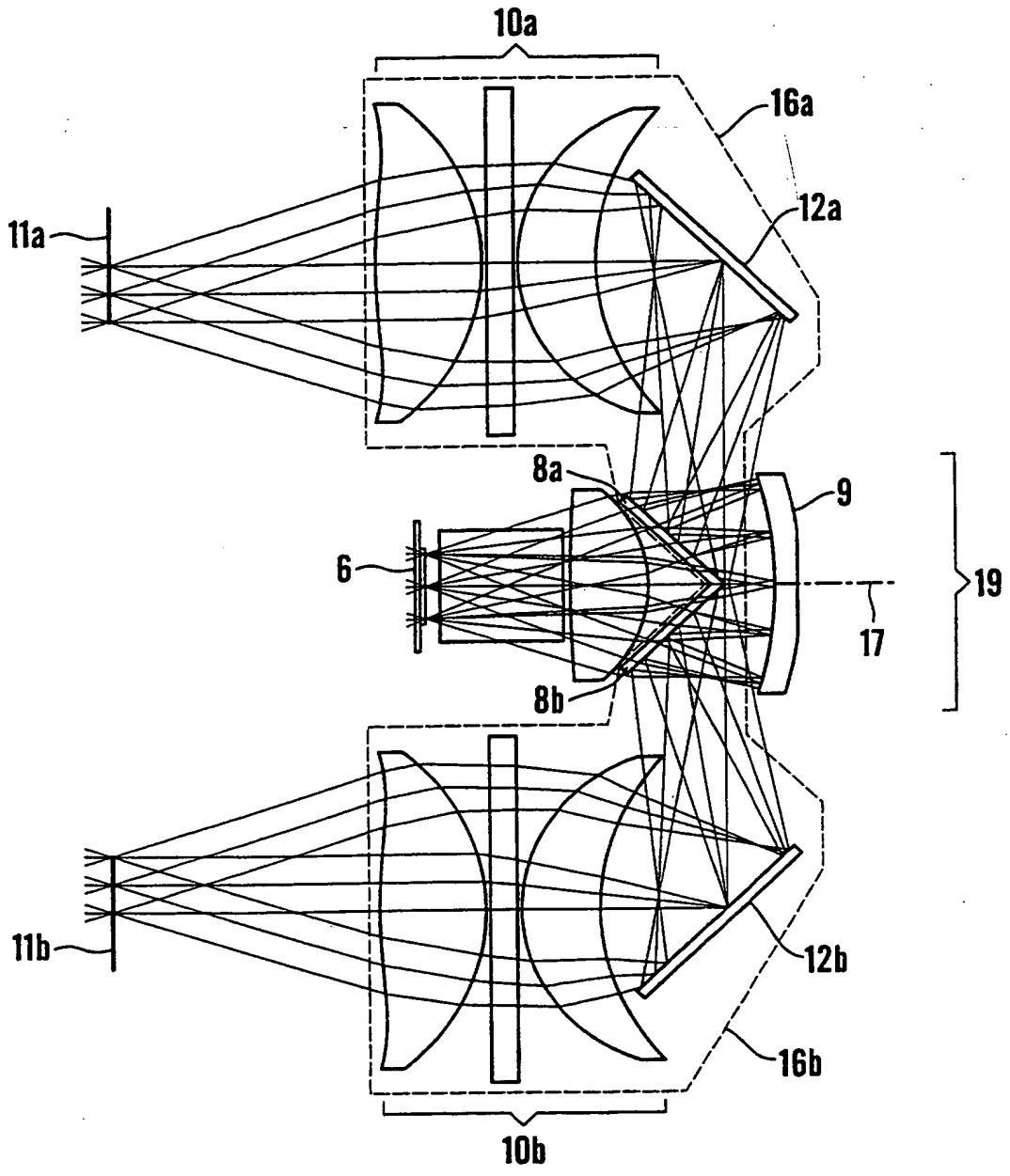


Fig.5

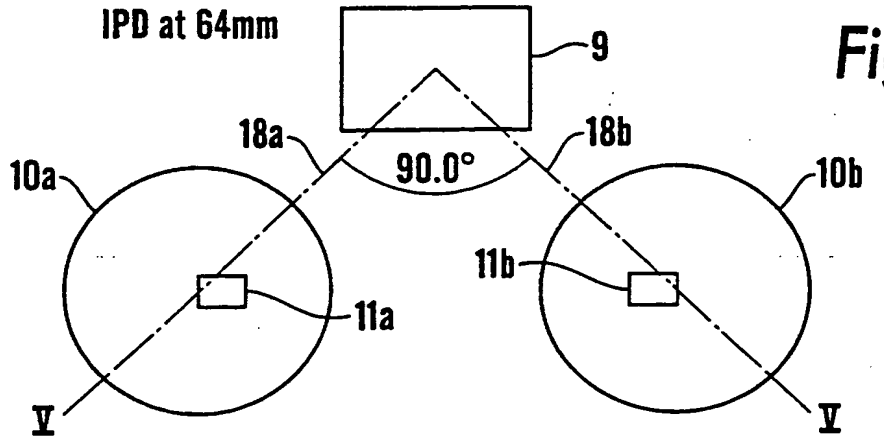


Fig.6

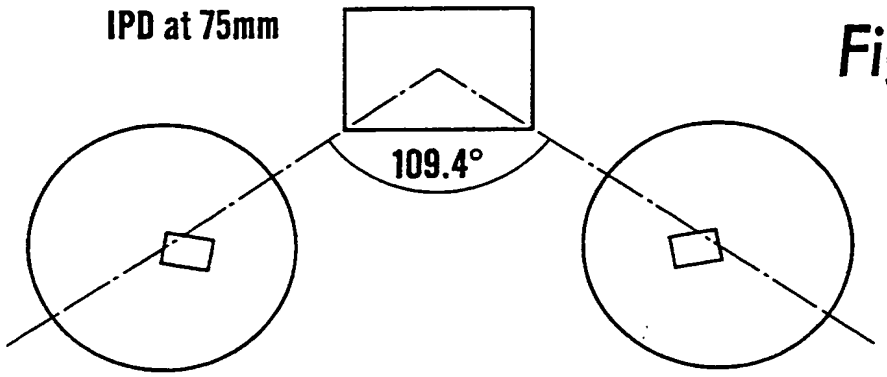


Fig.7

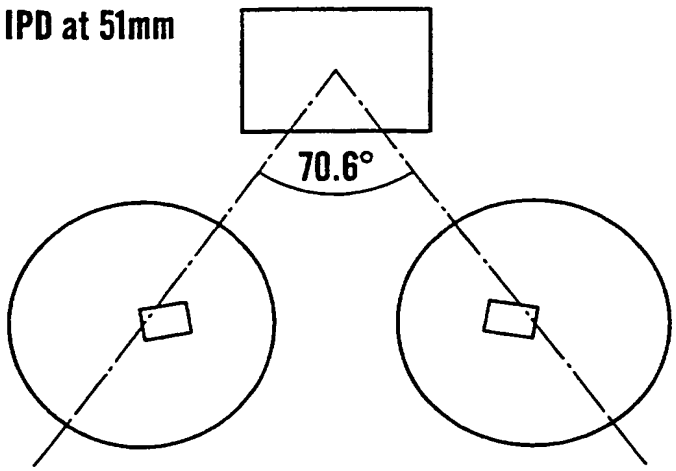


Fig.8

INTERNATIONAL SEARCH REPORT

Ir. ational Application No
PCT/GB 98/03744

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02B27/01

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 579 506 A (KAISER AEROSPACE & ELECTRONICS) 19 January 1994 see column 3, line 16 - column 5, line 23; figures 1-3	1-4,6, 11-15
Y	WO 85 04961 A (HUGHES AIRCRAFT CO) 7 November 1985 see page 9, line 8 - page 12, line 33; figures 1-3	1,2,6, 11,14,15
Y	US 5 418 584 A (LARSON BRENT D) 23 May 1995 see column 4, line 49 - column 5, line 8 see column 7, line 3 - line 20; figures 4A,4B	1-4,6, 11-13,15

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 March 1999	30/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Hessen, J

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 98/03744

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 0 395 570 A (UNITED TECHNOLOGIES CORP) 31 October 1990 see page 3, line 31 - page 4, line 7 see page 6, line 12 - line 23; figures 1-4	1,6,11, 15
A	EP 0 381 449 A (SYSTEMS RES LABOR) 8 August 1990 see abstract; figure 1	1,15

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

In ational Application No
PCT/GB 98/03744

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0579506 A	19-01-1994	CA 2100520 A	18-01-1994
		JP 6175067 A	24-06-1994
WO 8504961 A	07-11-1985	EP 0179124 A	30-04-1986
		JP 61501946 T	04-09-1986
		US 4968117 A	06-11-1990
		US 5035474 A	30-07-1991
US 5418584 A	23-05-1995	NONE	
EP 0395570 A	31-10-1990	US 4968123 A	06-11-1990
		CA 2015166 A	24-10-1990
		JP 3110593 A	10-05-1991
EP 0381449 A	08-08-1990	US 4915487 A	10-04-1990
		AU 626116 B	23-07-1992
		AU 4880590 A	09-08-1990
		CA 2008461 A	01-08-1990
		JP 2274249 A	08-11-1990